FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 7 No. 5, October, 2023, pp 18 - 23
DOI: https://doi.org/10.33003/fjs-2023-0705-1991

URBAN-RURAL DISPARITIES IN FOOD SECURITY: AN ANALYSIS OF HOUSEHOLD SURVEY DATA IN PLATEAU STATE, NIGERIA

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ABSTRACT

Food insecurity remains a critical concern in Nigeria, with significant disparities between rural and urban areas. This study aimed to assess differences in food security status between rural and urban households in Plateau State, Nigeria using discriminant analysis. Questionnaire data were collected from 140 households in one rural and one urban community. Eight measures of food security were assessed, including household size, income, food affordability and accessibility. Discriminant analysis results showed major differences between urban and rural households. Household size, food affordability and a tendency for food shortages were the most significant differentiating variables, with urban households having higher food security. The discriminant model correctly classified 89% of cases, demonstrating good predictive accuracy. Findings indicate substantial urban-rural disparities in food security, likely driven by factors like household size, income and food accessibility. Targeted policies and interventions in rural areas and for larger households may help address gaps in the affordability, availability and accessibility of food. Further research across wider geographic areas can validate and extend these results.

Keywords: Community, Discriminant, Food security, rural, urban

INTRODUCTION

Food security is a critical issue globally, and its importance cannot be overemphasized. The Food and Agriculture Organization (FAO) defines food security as a condition where all people have access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life (FAO, 2021). Despite efforts to improve food security worldwide, many countries, including Nigeria, still face challenges in ensuring food security for their citizens. Nigeria is Africa's most populous country and has a population of over 200 million people (World Bank, 2021). The country is heavily dependent on oil revenue, and agriculture is one of the primary sources of livelihood for many Nigerians (IMF, 2021). However, Nigeria has a high level of poverty, and food insecurity affects a significant proportion of the population (World Bank, 2021).

Food security can differ between rural and urban communities in Nigeria. Over 50% of Nigeria's population lives in rural areas, and agriculture is the primary source of livelihood (World Bank, 2020). In contrast, urban areas are characterized by high population density, and food is often imported from rural areas and other countries (FAO, 2021). This difference in the availability and accessibility of food between rural and urban communities may result in variations in food security levels.

Food security is a critical issue facing communities globally, particularly in developing countries. According to the Food and Agriculture Organization (FAO) of the United Nations, around 820 million people worldwide suffer from chronic undernourishment, and 2 billion people lack access to safe, nutritious, and sufficient food to meet their dietary needs. Food security is a significant concern in Nigeria, with millions of people facing challenges in accessing adequate and nutritious food. This issue affects both urban and rural communities, and understanding the differences between the two can help policymakers develop targeted interventions to improve food security.

A study conducted by Tafamel and colleagues (2020) applied discriminant analysis to assess the differences in food security between urban and rural households in Plateau State. The study used data from a survey of 1,200 households, with 600 households from urban areas and 600 from rural areas. The study found that the most significant variables that differentiated between the food security status of urban and rural households were education, income, and access to credit. The study found that urban households had higher food security levels than rural households due to better access to markets, higher incomes, and greater social support. However, the study also found that urban households had higher levels of food waste, with higher incomes leading to increased food consumption and waste.

A study by Omonona et al. (2019) analyzed nationwide household data from the General Household Survey Panel in Nigeria to compare food security status between urban and rural areas. Using discriminant analysis, they found that income, education level, and household size were the most significant variables differentiating the food security of urban versus rural households. Their results showed rural households had higher levels of food insecurity compared to urban households, likely driven by lower agricultural productivity, limited market access, and lower incomes in rural areas. Larger household sizes also contributed to greater food insecurity due to higher food consumption needs and inadequate income. The findings highlight key determinants of the urban-rural food security differential in the country.

Discriminant analysis is a statistical technique that can be used to identify the variables that differentiate between urban and rural community's food security status. In this article, we will examine the application of discriminant analysis to assess food security differences between an urban and a rural community in Plateau State, Nigeria.

Plateau State is located in the central region of Nigeria and is home to both urban and rural communities. Food insecurity is a significant issue in the state, with poverty, low agricultural productivity, and inadequate infrastructure contributing to the problem. Discriminant analysis can help policymakers identify the factors that affect food security in urban and rural communities in the state. The state has a population of over 4 million people (NPC, 2016). The state is known for its agricultural products such as potatoes, maize, and yams (Plateau State Government, 2021). However, food insecurity remains a significant concern in the state, with over 40% of the population living below the poverty line (National Bureau of Statistics, 2019).

Despite the efforts of the Nigerian government and international organizations to address food security challenges, there is a lack of comprehensive studies that compare food security between urban and rural communities in Plateau State. This knowledge gap is significant as it hinders the formulation of evidence-based policies to improve food security.

The objectives of this study are to identify the factors that affect food security in urban and rural communities in Plateau State, Nigeria and also to use discriminant analysis to predict food security in urban and rural communities in Plateau State, Nigeria.

The study's significance lies in its potential to contribute to the understanding of food security in Plateau State, Nigeria. It can also inform policies aimed at improving food security in the state. The study's findings may be useful to government agencies, non-governmental organizations, researchers, and other stakeholders interested in improving food security in Nigeria.

MATERIALS AND METHODS

Discriminant Analysis

Discriminant analysis is a versatile statistical technique used to investigate group differences using multivariate data. Originally developed by R.A. Fisher in 1936, it remains an accurate and robust method for classification. Discriminant analysis is exclusively for categorical outcome variables and involves three key phases - assessing group differences, explaining sources of variation, and classifying new observations into known categories based on predictor variables. The objective is to derive linear combinations of predictors that maximize separation between groups. Resulting discriminant functions generate scores used to assign observations to groups. When properly applied, discriminant analysis often yields models with accuracy rivalling modern complex methods.

In discriminant analysis, linear combinations of the predictor variables are derived to maximally discriminate between predefined groups. The analysis involves three main steps; first, the Discriminant functions are generated from a sample of observations with known group membership. Secondly, these functions are applied to new cases with measurements on the predictors but unknown group membership. And lastly, the functions are used to classify the new cases into groups.

The process extracts an initial discriminant function that provides the most overall separation between the groups. It then extracts successive uncorrelated functions that provide additional separation. Extraction continues until reaching the maximum number of functions, based on the number of predictors and groups. With two groups, there is only one discriminant function. The function's scores determine the classification of observations into groups.

Fisher's linear discriminant analysis (LDA) is a common technique for classification. It transforms multivariate observations into univariate discriminant scores that maximally separate group means. LDA assumes the populations follow normal distributions with equal covariance matrices. A pooled covariance matrix estimate is used across groups. The goal is to find the linear combination of predictors that maximizes the ratio of between-group variance to within-group variance of the univariate scores. The resulting linear discriminant function maximizes this ratio of between-group separation to within-group variance (Rencher & Christensen, 2012).

Discriminant analysis is a statistical technique that derives linear combinations of independent variables that best discriminate between predefined groups. The discriminant functions are generated from a sample of cases with known group membership and can then be applied to new cases with measurements for the predictors but unknown grouping.

The procedure automatically selects a first function that maximally separates the groups. It then chooses a second uncorrelated function that provides further separation, continuing until reaching the maximum number of functions determined by the predictors and groups. In two-group discriminant analysis, there is only one discriminant function. The discriminant score from the function classifies cases into one of two or more groups (Jain & Chandrasekaran, 2022).

Fisher's linear discriminant analysis (LDA) is a popular technique for classification. The goal of LDA is to find a linear combination of predictors that transforms multivariate observations into univariate discriminant scores that maximally separate the means of the predefined groups. LDA makes assumptions of normality and homoscedasticity, using a pooled covariance matrix estimate across groups rather than separate covariance estimates for each group. The resulting linear discriminant function maximizes the ratio of between-group variance to within-group variance on the univariate discriminant scores.

In discriminant analysis, a fixed linear combination of the predictor variables (x's) is formed. This generates discriminant function scores (y's) for each observation. The y scores take on values $y_{11}, y_{12}, \ldots, y_{1n_1}$ for the observations from the first group and values $y_{21}, y_{22}, \ldots, y_{2n_2}$ for observations from the second group, and so on for additional groups. The separation between the groups is then assessed by examining the difference between the group means ($\bar{y}_1$, $\bar{y}_2$, etc.) scaled in standard deviation units. Specifically, the separation is calculated as:

$$\text{separation} = \frac{|\bar{y}_1 - \bar{y}_2|}{s_y}, \quad (1)$$

where

$$W = \frac{\sum_{j=1}^{n_1}\left(y_{1j} - \bar{y}_1\right)^2 + \sum_{j=1}^{n_2}\left(y_{2j} - \bar{y}_2\right)^2}{n_1 + n_2 - 2}$$

is the pooled estimate of the variance. The objective is to select the linear combination of the $\boldsymbol{x}$ to achieve maximum separation of the sample means $\bar{y}_i$. This results in the linear combination $y = \hat{\boldsymbol{l}}'\boldsymbol{x} = (\bar{x}_1 - \bar{x}_2)'\boldsymbol{W}_{pooled}^{-1}\boldsymbol{x}$ which maximizes the ratio

$$\frac{(Squared\ distance\ between\ sample\ mean\ of\ y)}{(Sample\ variance\ of\ y)} = \frac{(\bar{y}_1 - \bar{y}_2)^2}{S_y^2} = \frac{(\hat{\boldsymbol{l}}'\bar{x}_1 - \hat{\boldsymbol{l}}'\bar{x}_2)^2}{\hat{\boldsymbol{l}}'\boldsymbol{S}_{pooled}\hat{\boldsymbol{l}}'} \quad (2)$$

The maximum of the above ratio is

$$\boldsymbol{D}^2 = (\bar{x}_1 - \bar{x}_2)'\boldsymbol{W}_{pooled}^{-1}(\bar{x}_1 - \bar{x}_2), \quad (\mathbf{3})$$

the Mahalanobis distance.

If the populations are assumed to follow multivariate normal distributions with a common covariance matrix across groups, additional inferential tests can be performed. Under this normality and homoscedasticity assumption, the significance of the discriminant functions in separating the groups can be assessed, and then a test of $\boldsymbol{H}_0$: $\mu_1 = \mu_2$ versus $\boldsymbol{H}_1$: $\mu_1 \neq \mu_2$ is accomplished by referring $\frac{n_1+n_2-p-1}{(n_1+n_2-2)p}\left(\frac{n_1 n_2}{n_1+n_2}\right)\boldsymbol{D}^2$ to an F-distribution with $v_1 = p$ and $v_2 = n_1+n_2-p-1$ degrees of freedom. If $\boldsymbol{H_o}$ is rejected we conclude the separation between the two populations is significant (Johnson and Wichern, 2007).

In discriminant analysis, the discriminant function is a linear combination of the predictor variables that best separates the predefined groups. The coefficients applied to each predictor act as weights that maximize differences between groups relative to within-group variability. The goal is to find weights that generate discriminant function scores where high values mostly come from one group and low values from another. Determining these optimal weights mathematically involves finding the eigenvectors of the within-groups covariance matrix inverse multiplied by the among-groups covariance matrix. The elements of the resulting eigenvectors are the canonical coefficients that define the discriminant function as the weighted linear combination of predictors that maximally discriminate between groups.

Wilks' lambda (Λ) indicates how well the discriminant functions separate the groups. It is calculated as the ratio of the within-groups covariance matrix determinant to the total covariance matrix determinant (Rencher & Christensen, 2012):

$$\Lambda = \frac{|S_W|}{|S_A|} = \prod_{j=1}^{m} \frac{1}{1+\lambda_j} \quad (4)$$

Where |Sw| is the within-groups covariance matrix determinant and |ST| is the total covariance matrix determinant. Wilks' lambda also relates to the eigenvalues (λj) of the discriminant function eigenvectors as follows (Rencher & Christensen, 2012). m is the minimum of $K-1$ and p, with K being the number of groups and p the number of predictors. Values of Λ near 0 indicate better discrimination.

The canonical correlation shows the association between the discriminant functions and the predictor variables. It is calculated for the jth discriminant function as:

$$r_{cj} = \sqrt{\frac{\lambda_j}{1+\lambda_j}} \quad (5)$$

The overall covariance matrix, T, is given as:

$$T = \left(\frac{1}{N-1}\right) S_T \quad (6)$$

The within-group covariance matrix, W, is given by:

$$W = \left(\frac{1}{N-K}\right) S_W \quad (7)$$

The among-group (or between-group) covariance matrix, A, is given by:

$$A = \left(\frac{1}{K-1}\right) S_A \quad (8)$$

The linear discriminant functions are given by:

$$y = \hat{\boldsymbol{l}}'\boldsymbol{x} = (\bar{x}_1 - \bar{x}_2)'\boldsymbol{W}_{pooled}^{-1}\boldsymbol{x} \quad (9)$$

The standardized canonical coefficients are given by:

$$v_{ij}\sqrt{w_{ij}} \quad (10)$$

where v_{ij} are the elements of V and w_{ij} are the elements of W.

The correlations between the independent variables and the canonical variates are given by:

$$Corr_{jk} = \frac{1}{\sqrt{w_{jj}}}\sum_{i=1}^{p} v_{ik}\, w_{ji} \quad (11)$$

For this work, the discriminant analysis was used to discriminate between urban and rural communities. This classification was done based on factors such as the size of the household, household income, accessibility to food, affordability of food, quality of food (balanced diet) and nature of the food (cultural).

Study Design

The study focuses on food security between urban and rural communities in Plateau State, Nigeria. The study area was limited to two local government areas, one urban and one rural. The study used discriminant analysis to predict food security levels and identify factors that affect food security.

The study was conducted using the Heipang District of Barkin-Ladi local government area as a rural community and the Bukuru metropolis located in Jos South local government area as an urban community both in Plateau State. A total of 150 questionnaires were issued to both urban and rural community heads of households in the communities, 100 for heads of rural community, and 50 for those in the urban community. A total of 140 responses were obtained, 92 from the rural community and 48 from the urban. This represents 93% of the total questionnaires administered. The predetermined groups for the analysis were, those located in the rural community and those in the urban community.

Data obtained was analysed using descriptive statistics and Discriminant Analysis with the aid of SPSS version 25. The discriminant analysis was used to first determine if the pre-determined populations were actually distinct and also to determine if the variables selected do distinguish between the two communities.

RESULTS AND DISCUSSIONS

Eight variables were entered to be able to discriminate between these groups, they are Household size, Food balance, Cultural food, Food affordability, Food accessibility, Family income and same meal.

Table 1: Test of Equality of Means

Test Variables	Wilks' Lambda	p-value
What is the size of your household?	0.513	0.000
How often do you experience food shortages in your household?	0.811	0.000
How balanced is the food you consume in your household?	0.937	0.003
The food you consume are they cultural food?	0.861	0.000
How affordable is the food you consume?	0.761	0.000
How accessible is your reach to the food you consume?	0.829	0.000
How adequate is your income to cover the food consumption in your household?	0.874	0.000
Is there a tendency to consume the same meal three times a day?	0.922	0.001

Table 1 shows the test of equality of means, it is discovered that the most discriminating variable between the two groups is the size of the household (0.513), followed by the affordability of the food (0.761), then the tendency to experience food shortage, in that order of the Wilks' Lambda. All the variables are significant, which implies that between the two communities, these variables are not the same.

Table 2: Box's Test of Equality of Covariance Matrices

Box's M		206.237
F	Approx.	5.316
	p-value	0.000

Table 2 shows the result of the Box's M test, the essence of Box's M is the test for equality of the covariance matrix, for discriminant analysis to be carried out, the covariance matrices must be equal. The p-value<0.05, which means there is no significant difference in the covariance matrices and so satisfies one of the conditions for the use discriminant analysis model.

Table 3: Eigenvalues and Wilk's Lambda

Canonical Correlation	Wilks' Lambda	Chi-square	p-value
0.771	0.406	116.225	0.000

Since there are two categories of grouping in the study, only one discriminant function was created, Table 4.3 shows the efficacy of the function created. The function has a Wilk's lambda value of 0.406. Also, the chi-square test is significant, this implies that function one carries most of the information concerning and can adequately separate between the two groups.

Table 4: Standardized Canonical Discriminant Function Coefficients

Variable	Coeff.
What is the size of your household?	0.704
How often do you experience food shortages in your household?	-0.351
How balanced is the food you consume in your household?	-0.190
The food you consume are they cultural food?	-0.090
How affordable is the food you consume?	0.365
How accessible is your reach to the food you consume?	0.170
How adequate is your income to cover the food consumption in your household?	0.082
Is there a tendency to consume the same meal three times a day?	-0.187

Table 4 shows the coefficients of the standardized canonical discriminant function.

$The\ discriminant\ function\ D\ is\ given\ by$:

$$\boldsymbol{D} = 0.704 * Household\ Size - 0.190 * Food\ Balance + 0.365 * Food\ Affordability - 0187 * Same\ meal - 0.090 * Cultural\ food - 0.170 * Food\ accessibility + 0.082 * Income.$$

It can be seen from the table that household size, followed by affordability among others has the largest absolute value, the larger the absolute value of the coefficient of a function is, the more discriminating ability it has. The standardized canonical function also buttresses the point earlier made from the test of equality of means.

Table 5: Classification results

	Location	Predicted Group Membership		
		Urban	Rural	
Count	Urban	46	2	48
	Rural	13	79	92
Percentage	Urban	95.8	4.2	100
	Rural	14.1	85.9	100

Table 5 shows the classification result, a good number of the cases were correctly classified, and the average correctly classified among the two groups is 89%, which leaves an apparent error rate of only 11%. According to Gagne (2014), a discriminant model is efficient if it can correctly classify up to seventy per cent of the cases. It can therefore be said that the discriminant analysis is an efficient model for classifying urban and rural households on food security.

Discussion

From the analysis, it can be observed that there is a big distinction in terms of food security between an urban and a rural community. All the variables selected in this study are significant, which means that the two communities are not on the same pedestrian when it comes to food security. The most discriminating factor is the size of the household, the average size of a household in the rural community is 3 to 4, while that of the urban community is not more than 2. This goes a long way to affect the food consumption of a household, this also affects the affordability, because there is a negative correlation between the affordability of food and the size of the household.

Discriminant analysis was effective in distinguishing between the food security status of urban and rural households in Plateau State, Nigeria. The discriminant model correctly classified 89% of cases, indicating good predictive accuracy. The most significant variables differentiating urban and rural households were household size, food affordability, and the tendency to experience food shortages. Urban households had better food security overall compared to rural households. The key finding from the discriminant analysis was the significant differences between urban and rural households in Plateau State, Nigeria in terms of food security status. The most discriminating variables were household size, food affordability, and a tendency for food shortages, with urban households demonstrating higher food security overall.

These results align with previous studies showing substantial disparities in food security between urban and rural areas, especially in developing countries like Nigeria. For example, Omonona et al. (2019) in their analysis of national household data in Nigeria also found income, education, and household size differentiated the food security status of urban and rural households. Similarly, a study in India by Bharati et al. (2022) identified income, household size, and food prices as key determinants of the urban-rural food security differential.

The reasons for rural households' greater food insecurity are multifaceted. As noted in this study, larger household sizes strain resources for food purchase and consumption needs. Rural populations also tend to have lower incomes and agricultural productivity, reducing physical and economic access to sufficient food (Sekhampu, 2012). Higher poverty rates are prevalent, and rural areas often suffer from inadequate infrastructure, markets, and services limiting food availability (FAO, 2019).

Urban locales conversely offer more diverse income sources, lower dependency ratios, and greater access to markets and government programs that enhance purchasing power and food entitlements (Anriquez et al., 2013). However, the study highlights that affordability issues remain, and urban low-income households still experience major food security challenges as well.

Methodologically, the high predictive accuracy (89% correct classification) of the discriminant model in distinguishing urban vs. rural households based on food security indicators demonstrates the value of multivariate analytical techniques for segmentation and policy analysis. Combining discriminant analysis with spatial mapping and regression approaches can provide greater nuance into drivers of food insecurity across geographical and socioeconomic divides (Omonona et al., 2019).

While these findings are consistent with existing literature, the relatively small localized sample limits generalizability. More extensive surveys across Nigerian states can validate results. Overall, the study provides strong evidence of the need for targeted food security interventions in rural areas and for policies improving agricultural productivity, income support, and food access in vulnerable communities.

CONCLUSION

There are substantial differences in food security status between urban and rural communities in Plateau State. The discriminant analysis provides evidence that targeted efforts are needed to improve food security for rural and low-income households in Plateau State to close the urban-rural divide. The study provides insights into major factors differentiating food security status across communities that can inform policymaking. Factors like household size, income, and food accessibility are major drivers of these urban-rural disparities in food security.

The work recommended that policies and interventions to improve food security should target rural areas and larger households. Secondly, Improving affordability, availability, and access to food in rural communities should be prioritized. Also, agricultural productivity enhancements, income support, and social safety nets for vulnerable groups may help reduce the urban-rural food security gap.

For further research, larger sample sizes cutting across the states of Nigeria will help validate findings and provide greater granularity on drivers of food insecurity across geographic and demographic segments.

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